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Wilhelm Althammer
Susanne Dröge

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DIW Berlin
German Institute for Economic Research
Königin-Luise-Str. 5
14195 Berlin
Tel. +49 (30) 897 89-0
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Ecological Labelling in North-South Trade

Wilhelm Althammer* Susanne Dröge†

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Abstract

We investigate in a horizontal product differentiation model with North-South trade the implications of a home bias in consumers' demand for labelled goods. We compare mutual recognition and international harmonisation of ecological labels with respect to firms' profits and welfare. Northern consumers perceive a warm glow from buying green, but have information problems with imported labelled products. Firms differ in labelling costs which could help a Southern firm to compensate for the home bias under mutual recognition. Under harmonisation the home bias disappears. Welfare analysis of harmonised labelling shows that a Southern firm gains from adopting a harmonised label – even if there is "eco-imperialism". Given the specific trade structure in our model, harmonisation is a beneficial regime except for the case that labelling costs reach a specific treshold.

Keywords: Ecological Labels; Product Differentiation; North-South Trade; WTO Rules

JEL classification: F13, F18, L13, Q56

*Leipzig Graduate School of Management – HHL, Jahnallee 59, 04109 Leipzig, althammer@macroec.hhl.de

†DIW Berlin – German Institute for Economic Research, Königin-Luise-Straße 5, 14195 Berlin, Germany, Tel.: +49 30 89789-689 (Fax: -113), E-mail: sdroege@diw.de.
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Contents

1 Introduction

Ecological labels help consumers to identify clean products with respect to a whole range of environmental criteria relating to consumption and production externalities. This makes them useful for the identification of processes and production methods (PPMs) of products which – with respect to their incorporated characteristics – are regarded as fully homogenous. Due to the rapid increase in trans-boundary and global environmental problems, there is a need to control for PPMs. Moreover, labelling in general has become an important national environmental policy tool.[1] Most eco-labelling programmes operate with voluntary participation of firms and all of them rely on market forces. However, international trade rules established by the World Trade Organization (WTO) do not allow governments to discriminate imports produced with environmentally unfriendly PPMs as they have to be treated in the same way as domestic 'like' products. Many exporting countries like Malaysia, Indonesia, Brazil, or Columbia, have introduced ecological labels in the 1990s (Basu et al. 2003). These labels compete with labels introduced in the importing countries for homogeneous products, such as timber, flowers, or cotton. Thus, discrimination of goods could also relate to the origin of the labelling programme. So far, in the WTO debate major attention has been paid to the labels' potential for 'like' product discrimination based on PPMs (Grote et al. 1999, Ahn and Ahn 2001, Melser and Robertson 2005, Greaker 2006), which is reflected also in the Doha Mandate of WTO trade negotiations (Doha Declaration 2001). Little attention has been paid to the competition between different labels for the same type of good and the consequences of information problems in export markets. Although homogeneous products carrying a foreign label must not be rejected at the border if the label uses different criteria than those underlying the domestic labels for 'like' products, consumers tend to prefer labels issued by domestic agencies. Thus, if labels should fulfill the role of fighting global pollution *without* compromising international agreements, esp. trade rules (as pointed out by Teisl et al. 2002: 356, Melser and Robertson 2005: 53, 57), acceptance of different labels needs

[1] We refer to *"the use of labels in order to inform consumers that a product is determined by a third party to be environmentally more friendly relative to other products in the same category"* as defined by the UNCTAD (1994). See also the International Organization for Standardization (ISO) definition: *"Type I is the eco-seal awarded as a license and based on a labelling programme"*(OECD 1997b: 9 f).

some form of agreement, too.

There are two options available for treating labelled goods in international trade. Either, trading countries negotiate mutual recognition of national labels or they negotiate a harmonised approach by introducing a common label, e.g. for specific products which could be regarded as 'like products' in WTO terms. While harmonisation would imply a single labelling programme with a single labelling seal for all participating countries, mutual recognition agreements (MRA) allow each nation to keep the national labelling scheme with a national label. The trade consequence from both regimes is identical when it comes to discrimination at the border: neither products bearing a harmonised label nor products bearing a foreign label under an MRA must not be denied market access. Moreover, as we focus on the international trade dimension and WTO regulation, the decision on both mutual recognition and harmonisation needs negotiations at the governmental level as private organisations do not have a mandate.

In this paper we look into the performance of either type of agreement in terms of welfare if a Northern and a Southern country engage in trading a homogeneous good. An important point in this respect is the different perception of trade in labelled goods in developed and in developing countries. On the one hand, in industrialised countries there are two motivations for ecological labels. First, many consumers prefer green goods and green production. Thus, they need information and they are willing to pay a premium. Second, for policy makers, labels indirectly help to set green standards. On the other hand, for developing countries the demand for green goods could bring along higher and costly standards. In order to consider their local and technological conditions they have an incentive to implement own labels for exports to markets with 'green' demand. Yet, as the labelling criteria set by importing countries could become technical standards which are beyond the scope of national policy, exporters and governments from the South fear a high potential for protectionism from Northern labels to which consumers ascribe a higher credibility.

Moreover, we ask how the strictness of labels varies if national labels would be mutually recognised or harmonised at the international level. The criteria could differ widely under mutual recognition if handled as under current WTO-rules. This changes under harmonisation as every producer who wants to acquire a label needs to follow international labelling criteria which are set by some kind of international institution.

For the implementation, a number of practical issues arise, which we will not address. To mention but a few, labels could be either based on broad life-cycle-analyses or on selected criteria. For the production of homogeneous goods one can implement single-subject labels (e.g. the FSC-Forrest Stewardship Council label for timber). Currently, the most common labelling approach is the use of multi-subject labels, which apply to a variety of products and which are installed as national labelling programmes like the *Green Seal* in the USA or the *Blue Angel* in Germany.

Basically two dimensions exist that describe product differentiation between goods, a horizontal and a vertical one. Each dimension is characterised by consumers' preferences (Neven and Thisse, 1990; Beath and Katsoulacos 1991). Two products differ in the *horizontal* dimension when there is no ranking among consumers based on their willingness to pay for the two goods, but the spatial proximity of goods to consumers' tastes matter. There is *vertical* product differentiation if goods are ranked according to the consumers' willingness to pay for quality (Neven and Thisse 1990: 175f). We apply a model of horizontal product differentiation in the Hotelling (1929) tradition and as in Eriksson (2004), where all consumers reveal the same willingness to pay. This reflects a country's average willingness to pay for environmental friendliness, which differs between developed and developing countries.

We also take into account that consumers experience 'impure altruism' as defined by Andreoni (1989, 1990). This means that they experience a warm glow from contributing to environmental protection, leading to a higher willingness to pay for green goods and an incentive for firms to adopt a label. Moreover, we analyse a situation where consumers reveal a 'home bias' with respect to a Northern label, meaning that they discriminate Southern products due to asymmetries in information about the credibility of the Southern label. Consumers choose the product which they feel is located in a horizontal dimension closest to their taste. Without labelling, this is determined only by the origin of a firm, North or South. A label explicitly adds the environmental quality dimension to this localisation. However, unlike in Eriksson (2004), this does not imply that products are at different ends of a quality scale. Rather, with the labels applied, consumers *perception* of the products environmental characteristics depends on the label as such, and on the origin of that label. Thus, the label is part of the taste dimension related to a homogeneous good.

Instead of comparing an autarky scenario to a trade scenario – as can be found in Jansen and de Faria (2002) or Mäkönen (2005) – we assume that the Southern firm exports all its output to the domestic market. We find that under mutual recognition each firm would choose a labelling level which optimises its profits, and that the Northern policy maker under this regime would also choose these labelling criteria. Moreover, we show that an adoption of a label is always a dominant strategy in our setting. Even the application of the importing country's label to the exporting country's firm ("eco-imperialism") could be optimal for the Southern firm.

Welfare analysis of a harmonised labelling programme shows that a social planner would set stricter labelling criteria compared to the mutual recognition case if the difference in labelling costs is sufficiently large. Stronger labelling standards help to increase profits and market share of the 'cheaper' firm. Jansen and de Faria (2002) as well as Mäkönen (2005) arrive at different results in models of vertical product differentiation. In their studies, mutual recognition can drive high quality out of the market due to adverse selection. We do not confirm this. Under mutual recognition, the Southern firm can compensate the home bias via labelling costs. This could support a self-fulfiling prophecy of the Northern consumers' prejudice concerning a Southern countries labelling quality. Under harmonisation and depending on the cost differentials between firms, an efficient outcome could be that the social planner sets the criteria for the common label at such a level that the cheaper firm takes over the whole market.

In the next chapter, we analyse mutual recognition and harmonisation in three steps. First, we show the market equilibrium and welfare for a unilateral introduction of a label in the North. Second, we investigate mutual recognition of labels in both countries. Third, we turn to welfare results for harmonisation of labels at the international level. Chapter 3 summarises and concludes.

2 North-South trade in labelled goods: a model

Trade between industrialised and developing countries has specific characteristics, for example a high export dependency by developing countries with respect to a few specific product groups (e.g. natural resources,

agricultural products). Moreover, many Southern exporters have a deep mistrust against any environmental requirement related to traded products. Nevertheless, labels are known as one of the least trade restrictive tools and, thus, are the lowest common denominator when it comes to making transparent the social and environmental production methods in countries of origin. Especially in the industrialised countries this tool has a long tradition, and an increasing number of less developed countries introduces labels, too.

Labels enable producers to differentiate their products in two dimensions. Either labels help to indicate (environmental) quality, that is products are vertically differentiated and consumers can rank them according to their tastes for quality. Or labels help to differentiate products in a horizontal manner, meaning that product characteristics are 'located' close to consumers tastes without any ranking of consumers' willingness-to-pay for the different types (Tirole 1989; Neven and Thisse 1990, 175f). For the analysis of non-product-related labelling, the latter differentiation is relevant, as by assumption the environmental effect is related to production and it is not reflected in the product's quality. As we assume that consumers have information problems with respect to the Southern firm, the labels add another identification mark to the products origin. As consumers have a benefit from buying labelled instead of unlabelled goods, the label affects the consumers location, prices and profits.

We illustrate the effect of labels in three steps. First, only the home (Northern) country introduces a label, a, which the firm would adopt as long as this leads to positive profits, i.e. as long as the extra revenue is not overcompensated by extra production cost (e.g. process innovation, bureaucracy, monitoring). Second, we consider that both firms use a label in order to increase market shares. With labelling, firms' products are differentiated not only through location (Northern and Southern) but also through ecological labels (labelled and non-labelled), while products are still physically homogenous. If only one firm introduces a label, this opens up a differentiation with respect to the perceived environmental "quality" of the good (the PPMs).[2] Third, we ask how a harmonisation of labelling regimes affects welfare and the level of labels.

We do not include a quality dimension, because we do not consider any consumer ranking. Instead, we assume that all of the consumers prefer clean production in the same way (assuming to represent a country's

[2]For a combination of the vertical and the horizontal differentiation dimensions in one model see Neven and Thisse (1990).

attitude to the environment), i.e. there is no separation of the market depending on horizontal or vertical domination (Greaker 2006, Neven and Thisse 1990). Sticking to the simple horizontal differentiation means that only in the case in which the Southern firm does not use a label do firms differ in both location and labelling. In our model, national labels simply add a characteristic to location; this assumption enables us to isolate one of the major problems of developing countries' labels, namely that they face a home bias of consumers in the export market. A home bias means that Northern consumers prefer the Northern label over the Southern one. A home bias is motivated by information problems with respect to the labelling criteria abroad, the reliability of the labelling system (e.g. monitoring), a credibility bonus for the Northern firm based on the consumers' perception, e.g. because of long-standing labelling experiences in the North, where a combination of labelling and environmental management certification systems have led to a low level of monitoring failure. If, however, the governments decide to introduce a harmonised single subject label, and both firms accept this tool, the firms' differentiation stems solely from the costs of labelling.[3]

2.1 Introducing a label in the North

We start with a simple model of spatial product differentiation and a duopolistic market on which two firms - a Northern producer and a Southern one - compete in prices. Firms are differentiated by their location and although their products are fully homogenous, the location leads to a differentiation in the spatial dimension, because consumers face transportation cost. Following the horizontal differentiation model of Hotelling (1929), we assume that consumers and products are located along a line of potential locations. The producers are located along the unit intervall at 0 (Northern firm) and 1 (Southern firm), whereas consumers are uniformly distributed over the unit intervall. Consumers have individual tastes for products. They make their decisions in a rational manner, comparing prices of goods with the proximity of goods to their ideal location. Accordingly, a market equilibrium is determined by the goods' prices, the distribution of consumers, the price, and the location of the rival product. We also assume that the Southern firm produces only for the Northern market, i.e. it exports all its output. Each con-

[3]Basu et al. (2004: 136) pronounce that in segmented markets the credibility problem of labelling programs "is key to the determination of the green premium".

sumer x wants to buy one unit of the product q, i.e. demand is inelastic. Consumer $x \in [0,1]$ has a willingness to pay for a good q of

$$\nu(q,x) = s + b(a) - tx^2. \tag{1}$$

where s is the gross utility from consuming q (assumed to be large enough so that all consumers buy), t is the cost each consumer faces when buying in different locations (transport cost), which we normalise to 1 to keep notation simple. $b(a)$ is the individual benefit from contributing to the environment, depending on the actual label chosen, with $b(0) = 0$, $b'(a) > 0$ and $b''(a) < 0$. a represents the ecological labelling scheme which includes abatement technology, but also other criteria (e.g. auditing, process innovation, technological innovation or waste management). Labels can be chosen from the possibility set $A = [a^{min}, a^{max}]$, where a^{min} denotes minimal ecological requirements that have to be met to induce a positive willingness to pay, and a^{max} denotes the maximal ecological requirements for which consumers are willing to pay. We do not assume that there is a direct impact in consumer utility (or social welfare) from a "greener" production. Rather, consumers want to contribute to a better environment in general, regardless of their individual benefit.[4]

The model consists of a three stage game. In the first stage, the Northern government chooses a labelling scheme $a^N \in A$. In the second stage, the Northern firm decides upon adopting the label or not. In the third stage, both firms set their prices in a non-cooperative manner. The Northern firms' cost function is $C_1(q_1, a) = (c + c_1(a))q_1$, with c representing constant marginal costs and $c_1(a)$ labelling costs. For the latter, we assume $c_1(0) = 0$, $c_1' > 0$ and $c_1'' > 0$. Labelling costs $c(a)$ include all relevant aspects of labelling at the firm level (e.g. process innovation, bureaucracy, monitoring). The Southern firms' cost function is $C_2(q_2) = cq_2$, i.e. there are no differences in production costs. To simplify notation, production costs are normalised to 0.

We start with calculating the market equilibrium and firms' equilibrium profits in the third stage. Utility of consumer x when buying from the Northern firm at 0 is defined as

[4]Examples for such an environmental awareness are concerns about animal welfare in agricultural production or contributions to a global public good, of which the benefits occur only over a long time period or in a different location. Moreover, also requirements which have an impact only on a small regional scale in a distant country are relevant here, e.g. farming methods abroad.

$$U_x^0(q_1, x) = s + b(a^N) - x^2 - p_1. \tag{2}$$

with a^N as the Northern label. Utility from buying the Southern good at 1 is

$$U_x^1(q_2, x) = s - (1 - x)^2 - p_2. \tag{3}$$

In order to determine the demand for each firm, we need to find the indifferent consumer, $\hat{x} \in [0, 1]$ - with superscript n indicating the scenario with Northern labelling - by equating (2) and (3) and solving for $\hat{x}^n$:

$$\hat{x}^n = \frac{b(a^N) + p_2 - p_1 + 1}{2} \tag{4}$$

Consumers who are located at $x < \hat{x}$ buy from firm 1 and consumers located at $x > \hat{x}$ buy from firm 2. Demand functions for the two firms thus are

$$D_1(p_1, p_2) = \hat{x}, \tag{5}$$

$$D_2(p_1, p_2) = 1 - \hat{x}. \tag{6}$$

As can easily be seen, without labelling identical prices would place the indifferent consumer at 1/2. With labelling, more consumers buy from the Northern firm located at 0, and it is conceivable that with identical prices the Northern firm attracts all the demand if the consumers' benefit is large enough. We find that $\hat{x} = 1$ if $b(a^N) = 1$. That is, if the benefit from buying the labelled good equals the transportation cost of buying from firm 1, the Northern firm attracts all demand. Thus, if prices do not differ, the Southern firm can only sell its product if the warm glow from buying the labelled good does not compensate for transportation cost, i.e. $(1 - \hat{x}^n) > 0$ if $b(a^N) < 1$.

In order to find the market equilibrium we need the Nash equilibrium for price competition. Profits of the Northern and the Southern firm are

$$\pi_1 = (p_1 - c_1(a^N))D_1(p_1, p_2), \quad \pi_2 = p_2 D_2(p_1, p_2), \tag{7}$$

and the reaction functions are

$$p_1^n(p_2^n) = \frac{1}{2}[p_2^n + b(a^N) + c_1(a^N) + 1] \tag{8}$$

$$p_2^n(p_1^n) = \frac{1}{2}[p_1^n - b(a^N) + 1] \tag{9}$$

The reaction functions show that firms pricing behaviour depends on the benefit consumers derive from Northern labelling. The Southern firm decreases its price if the benefit from the Northern label increases, while the Northern firm will use the benefit for an increase in the product's price. These reaction functions yield the equilibrium prices

$$p_1^{*n} = 1 + \frac{1}{3}[b(a^N) + 2c_1(a^N)] \tag{10}$$

$$p_2^{*n} = 1 - \frac{1}{3}[b(a^N) - c_1(a^N)] \tag{11}$$

Inserting the equilibrium prices into (4) gives the indifferent consumer's location:

$$x^{*n} = \frac{1}{2} + \frac{1}{6}[b(a^N) - c_1(a^N)], \tag{12}$$

which determines demand for the Northern firm, and

$$1 - x^{*n} = \frac{1}{2} - \frac{1}{6}[b(a^N) - c_1(a^N)], \tag{13}$$

which determines demand for the Southern firm. Inserting (12) and (13) into (7) yields the firms' profits

$$\pi_1^{*n} = \frac{1}{2} + \frac{1}{18}[b(a^N) - c_1(a^N)]^2 + \frac{1}{3}[b(a^N) - c_1(a^N)] = 2(x^{*n})^2 \tag{14}$$

$$\pi_2^{*n} = \frac{1}{2} + \frac{1}{18}[b(a^N) - c_1(a^N)]^2 - \frac{1}{3}[b(a^N) - c_1(a^N)] = 2(1 - x^{*n})^2 \tag{15}$$

.

Next we turn to the second stage. The Northern firm will adopt the label if adoption increases its profits compared to the situation without labelling. In the latter case, its profits are 1/2. Equation (12) shows that labelling increases profits if $b(a^N) > c_1(a^N)$, i.e. if the willingness to pay for a label is larger than the costs of labelling.

In the first stage, governments maximise welfare. The welfare in the Northern country includes the Northern firm's profits (π_1^{*n}), and the consumer surplus which consists of net consumer surplus (CS_{net}), the warm glow effect (WG), and transportation cost (TC), which each consumer

experiences as a disutility from the location of the two goods at either end of the horizontal line.[5]

$$W_N^n = \pi_1^{*n} + CS_{net}^n + WG - TC, \tag{16}$$

with $CS_{net}^n = s - p_1^{*n}x^{*n} - p_2^{*n}(1 - x^{*n})$, $WG = b(a^N)x^{*n}$, and $TC = \int_0^{x^{*n}} y^2 dy + \int_{x^{*n}}^1 (1-y)^2 dy = \frac{1}{3} + (x^{*n})^2 - x^{*n}$.

Inserting the results from (10) to (14) in (16) and using the constant $\sigma = s - \frac{7}{12}$ we get

$$W_N^n = \sigma + \frac{1}{12}[b(a^N) - c_1(a^N)]^2 + \frac{5}{6}[b(a^N) - c_1(a^N)]. \tag{17}$$

Maximising (17) with respect to a^N results in the first order condition

$$\frac{\partial W_N^n}{\partial a^d} = \frac{5}{6}(b'(a^d) - c'(a^d) + \frac{1}{6}(b(a^d) - c(a^d))(b'(a^d) - c'(a^d)) = 0 \tag{18}$$

.

This implies $b'(a^N) = c'(a^N)$, i.e. the marginal willingness to pay for the labelled good must equal the marginal labelling costs of the firm.

The welfare maximising label is identical to the one chosen at the firm level. For the Northern firm, profit maximisation requires $\frac{\partial \pi_1^{*n}}{\partial a^N} = 4x^{*n}\frac{\partial x^{*n}}{\partial a^N} = 0 \Leftrightarrow b'(a^N) = c'(a^N)$. This result is based on two assumptions. First, all consumers have the same willingness to pay for labelled products, and marginal benefit equals average benefit from consuming a labelled good. Therefore the label that maximises monopoly profits is the same as the welfare maximising one (Spence 1975).[6] Second, we have not included any social costs in the welfare function.[7]

Proposition 1. *If $b(a^N) > c_1(a^N)$, the introduction of a labelling scheme increases the market share and the profit of the Northern firm at the expense of the Southern firm.*

[5] As mentioned before, to simplify the analysis we do not assume that labelling increases welfare via the reduction of negative environmental externalities. Therefore, we analyse labels which have a perceived environmental impact, but not a measurable one.

[6] Under the assumption that all consumers have the same willingness to pay for quality, Spence (1975) has analysed the quality choice of a firm and has shown that the quality chosen by a profit maximising monopolist is identical to the welfare maximising quality, since then the marginal benefit of quality equals the average benefit.

[7] If a negative externality is included in the welfare function, the condition for a welfare maximum will be that the marginal costs of labelling have to equal the marginal disutility from pollution. See e.g. Eriksson (2004: 286).

Proof. Due to our symmetry assumptions, in the Bertrand competition equilibrium without labelling there are equal market shares (1/2), equal prices ($p_1^* = p_2^* = 1$) and equal profits ($\pi_1^* = \pi_2^* = \frac{1}{2}$). Proposition 1 can be seen directly from comparing (12) and (14) with these values. □

Compared to the case without labelling, the Northern demand has increased by $\frac{1}{6}[b(a^N - c_1(a^N)]$. If $\frac{1}{6}[b(a^N - c_1(a^N)] > 3$, all demand is directed to the Northern firm.

2.2 Labelling in both countries with mutual recognition

If we consider that both countries introduce a label, there are two potential ways to regulate the international trade in labelled goods. Either countries agree on mutual recognition or on harmonisation.[8] We investigate first a situation with mutual recognition. We consider a situation where countries take the labelling policy of other countries as given and do not stipulate any import rules for labelled or unlabelled 'like products'.

Introducing a label for the export good enables also the Southern firm to signal an environmentally friendly production and to gain from the consumers' willingness to pay. A Southern label could (re)gain market shares which would be lost if only the North introduces a labelling policy. However, we also assume that Northern consumers have a home bias, i.e. although they feel a benefit from buying a labelled Southern good instead of an unlabelled one, this benefit could be very low due to lack of credibility and consumers perceive a higher benefit from the home label. The home bias is expressed in terms of the difference between the benefits consumers experience from buying a labelled Northern and a labelled Southern good. Thus, $b(a^N) - b(a^S) > 0$ if $a^N = a^S$. This definition would imply that the Southern firm could compensate for the home bias by choosing a higher labelling level. A stronger definition of the home bias would be that $b(a^N) - b(a^S) > 0 \ \forall \ a^N, a^S \in A$. With the strong definition, even with the highest labelling standard applied in the South, consumers experience a lower benefit from the Southern compared to the Northern product. In the following, we assume the strong definition.

[8] Currently, neither agreement is prevalent under WTO rules, and as a matter of fact, labelled goods cross borders without explicit rules.

The critical consumer $\hat{x}^m$ is indifferent between buying from the Northern or from the Southern firm if governments choose to mutually accept the labels, superscript m indicating this situation. Utility from the domestic goods is

$$U_x^0(q_1, x) = s + b(a^N) - x^2 - p_1 \tag{19}$$

and utility from buying the Southern good is

$$U_x^1(q_2, x) = s + b(a^S) - (1 - x)^2 - p_2 \tag{20}$$

Equating (19) and (20) allows to solve for $\hat{x}^m$:

$$\hat{x}^m = \frac{b(a^N) - b(a^S) + p_2 - p_1 + 1}{2}. \tag{21}$$

If we assume that $p_1 = p_2$, consumers would split their demand between the two firms according to the differences in benefits from labelling. However, the difference in willingness to pay and in labelling costs will influence the equilibrium prices. The critical consumer is determined by both, price differences and differences in environmental benefits and the trade-off between the two characteristics.

Starting again with the third stage, firms' profits are

$$\pi_1 = (p_1 - c_1(a^N))D_1(p_1, p_2),\ \pi_2 = (p_2 - c_2(a^S))D_2(p_1, p_2). \tag{22}$$

Solving the first order conditions yields the equilibrium prices

$$p_1^{*m} = \frac{1}{3}[b(a^N) - b(a^S) + 2c_1(a^N) + c_2(a^S) + 3] \tag{23}$$

$$p_2^{*m} = \frac{1}{3}[-(b(a^N) - b(a^S)) + 2c_2(a^S) + c_1(a^N) + 3] \tag{24}$$

Firm 1's equilibrium price increases with the benefit consumers experience from domestic labels and decreases the more consumers value the Southern label. For firm 2, the inverse holds, meaning that the home bias influences the pricing behaviour of the two firms. Moreover, also the costs of labelling lead to an increase in prices for both firms, with a higher impact from the country's own label. The location of the critical consumer is now:

$$\hat{x}^m = \frac{1}{2} + \frac{1}{6}[b(a^N) - b(a^S) + c_2(a^S) - c_1(a^N)] \tag{25}$$

$$1 - \hat{x}^m = \frac{1}{2} - \frac{1}{6}[b(a^N) - b(a^S) + c_2(a^S) - c_1(a^N)] \tag{26}$$

The demand for the Northern firm depends upon the trade-off between the home bias and the difference in labelling costs. If $\beta \equiv b(a^N) - b(a^S) > 0$ denotes the home bias and $\gamma \equiv c_2(a^S) - c_1(a^N)$ denotes the cost differential, (25) shows that β shifts demand in favour of the Northern firm, and that γ shifts demand in either direction depending on the algebraic sign.

Equilibrium profits under mutual recognition are

$$\pi_1^{*m} = \frac{1}{18}[3+(b(a^N)-c_1(a^N))-(b(a^S)-c_2(a^S))]^2 = \frac{1}{18}[3+\beta+\gamma]^2 \tag{27}$$

$$\pi_2^{*m} = \frac{1}{18}[3-(b(a^N)-c_1(a^N))+(b(a^S)-c_2(a^S))]^2 = \frac{1}{18}[3-\beta-\gamma]^2 \tag{28}$$

Not surprisingly, the Northern firm's profit rises and the Southern firm's profit falls with the home bias. Moreover, the Northern profit rises with the Southern labelling cost and vice versa.

In the second stage, firms will adopt the label if this increases their profit. As can be seen from (27) and (28), this will be the case if $b(a^N) > c_1(a^N)$ and $b\left(a^S\right) > c_2\left(a^S\right)$, respectively.

In the first stage, governments choose independently the labelling requirements by maximising national welfare. As before, Northern welfare consists of profits, consumer surplus, warm glow effects and travelling costs, with warm glow being now $WG = b(a^N)x^{*n} + b(a^S)(1 - x^{*n})$. Inserting the relevant equations and maximising with respect to a^N again yields $b'(a^N) = c'(a^N)$ as a necessary condition. Southern welfare is assumed to consist only of the Southern firm's profits, maximising yields $b'(a^S) = c'(a^S)$ as a necessary condition.

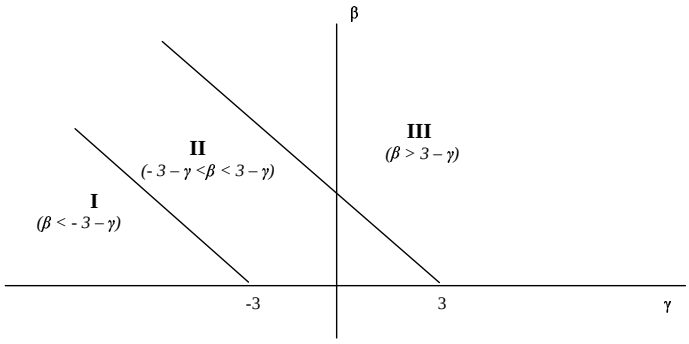
Proposition 2. *If $b(a^S) > c_2(a^S)$, the Southern firm gains from the introduction of a Southern label. Compared to the equilibrium without labelling, it can increase its market share and profit only if it has a positive and sufficiently high cost advantage ($-\gamma > \beta > 0$). For the market equilibrium, three regions can be distinguished, with both firms active only if $-3 - \gamma < \beta < 3 - \gamma$.*

Proof. The first sentence follows from comparing (26) with (13). The second from comparing (28) with 1/2. From (25) follows that $0 < \hat{x}^m < 1$ requires $-3 - \gamma < \beta < 3 - \gamma$.

□

We demonstrate the trade-off between home bias and cost differential in figure 1. It shows three regions. In region I, the home bias is small and the cost differential leads consumers to buy only from the Southern firm. In region II, there is horizontal product differentiation between the two firms and consumers buy both varieties. In region III, consumers buy only from the Northern firm, because there is a large home bias, compared to the cost difference.

Figure 1: Cost Differences and Home Bias



As a result we find that for the market equilibrium, the introduction of the Southern label does not automatically lead to a symmetric situation, because consumers in the North do not regard the two labels as being equivalent. For the Southern firm, the only way to compensate for the loss in market share caused by the home bias is to compete via the labelling costs. Only if the Southern firm's labelling programme is sufficiently cheaper than the Northern one, it could keep the benchmark market share (no labelling, profits = 1/2), or increase it. The problem is

that these national labels will in general not maximise worldwide welfare. On the one hand, differences in labelling costs are a comparative advantage, therefore production of labelled products should be shifted into the country with the lower costs. This tendency is dampened by the fact that a shift of production increases transport costs. On the other hand, consumer preferences are distorted due to informational constraints. Even if both labelling regimes are equal from a technical point of view, the perceived utility could differ. One way to handle this problem would be to give Northern consumers more reliable information about Southern production conditions by harmonising labelling requirements in a unified labelling programme.

2.3 Harmonisation of labels

A harmonisation of labelling programmes would need either close cooperation of national policy makers or an international institution that decides on the labelling programme and criteria. Harmonisation could induce either a lower or a higher level of labelling criteria. If there was an international social planner who had all relevant information, she could set the optimal labelling requirements with respect to world welfare. Actually, an international standard setting institution could be closest to this theoretical solution (like the ISO, taking care of technical standards or the Forest Stewardship Council, taking care of timber labelling). This institution could decide on a labelling programme and then assist national governments in implementation. If this solution is not feasible, national governments could engage in negotiations about labels for homogeneous goods - then it is a matter of the negotiation framework whether agreement leads to higher or lower than average criteria.

In the horizontal differentiation model, we assume that a harmonised single subject label provides to the Northern consumer more credible information with respect to the imported labelled good. Consumers no longer can distinguish a product according to the origin of its label. Harmonisation would bring about a single label, $\bar{a}$, for both products, Northern and Southern. As before, consumers feel they benefit from the label that certifies an environmentally friendly production method, but now there is no home bias. Instead, there is a symmetric situation in consumers' demand. Consumers' benefit from labels is now expressed by $b(\bar{a})$. Utility from the Northern good is now

$$U_x^0(q_1, x) = s + b(\bar{a}) - x^2 - p_1 \tag{29}$$

and utility from buying the Southern good is

$$U_x^1(q_2, x) = s + b(\bar{a}) - (1 - x)^2 - p_2. \tag{30}$$

Equilibrium prices in the third stage if both firms adopt to the label are:

$$p_1^{*h} = \frac{1}{3}(3 + 2c_1(\bar{a}) + c_2(\bar{a})) \tag{31}$$

$$p_2^{*h} = \frac{1}{3}(3 + c_1(\bar{a}) + 2c_2(\bar{a})). \tag{32}$$

The difference in prices now depends on the costs of labelling, $c_i(\bar{a})$. Following the usual procedure we arrive at the critical consumer

$$\hat{x}^h = \frac{1}{2} + \frac{1}{6}(c_2(\bar{a}) - c_1(\bar{a})), \tag{33}$$

who determines the demand for the Northern firm's product, and

$$1 - \hat{x}^h = \frac{1}{2} - \frac{1}{6}(c_2(\bar{a}) - c_1(\bar{a})), \tag{34}$$

the demand for the Southern product. Profits are

$$\pi_1^{*h} = \frac{1}{18}([3 + c_2(\bar{a}) - c_1(\bar{a})]^2 = \frac{1}{2} + \frac{1}{18}[c_1(\bar{a}) - c_2(\bar{a})]^2 - \frac{1}{3}[c_1(\bar{a}) - c_2(\bar{a})] \tag{35}$$

$$\pi_2^{*h} = \frac{1}{18}[3 + c_1(\bar{a}) - c_2(\bar{a})]^2 = \frac{1}{2} + \frac{1}{18}\underbrace{[c_1(\bar{a}) - c_2(\bar{a})]^2}_{>0} + \frac{1}{3}\underbrace{[c_1(\bar{a}) - c_2(\bar{a})]}_{\lessgtr 0} \tag{36}$$

Obviously, the difference between the two firms and the market equilibrium now depends on the costs of the harmonised label. In the Hotelling model, the assumption of identical production cost is important to focus on consumer preferences and their effect on the market equilibrium. Here, we consider instead the effects which occur if the labelling regime entails a cost difference, while preferences are *not* affected (as the home bias disappears). Thus, there are three cases. First, if $c_1(\bar{a}) = c_2(\bar{a})$, harmonisation leads to a symmetric situation in the

market. Firms have identical market shares and profits, as in the basic model without labelling. Second, if $c_1(\bar{a}) < c_2(\bar{a})$ the Northern firm has lower costs from labelling than the Southern firm. This cost advantage affects prices and profits. From (31) and (32) it can be seen that the Northern firm increases its price to a lower degree than the Southern firm and thus increases its market share and profits, see (33) to (36). Third, if $c_1(\bar{a}) > c_2(\bar{a})$ the Southern firm will attract more demand and gain higher profits. The profit functions (35) and (36) illustrate the two effects clearly: the first term is the benchmark profit (1/2), the second term is the profit gain from the price reactions, which is always positive, and the third term depends on which firm has the lower costs. If there is a cost disadvantage, the third term overcompensates the second term, leading to a lower profit than the benchmark.

In the second stage, firms choose simultaneously whether to adopt the label or not. For this decision, they compare their profits under multilateral, under unilateral adoption and under non-adoption. If none adopts, profits are 1/2 for each. If only the Northern firm adopts, its market share is given by $x = \frac{1}{2} + \frac{1}{6}[b(\bar{a}) - c_1(\bar{a})]$, in the case that only the Southern firm adopts, its market share is $(1 - x) = \frac{1}{2} + \frac{1}{6}[b(\bar{a}) - c_2(\bar{a})]$ (see (13)). If both adopt, profits are given in (35) and (36).

Proposition 3. *If $b(\bar{a}) > c_i(\bar{a})$, $i = 1, 2$, adopting the label is a dominant strategy.*

Proof. Without loss of generality, let us assume that $c_1(a) < c_2(a)$. It is evident from (33) to (36) that the Northern firm gains from adopting the label independently of Southern's decision. If the Southern firm adopts too, its market share is given by (34). If it decides not to adopt, its market share is $1 - x = \frac{1}{2} - \frac{1}{6}[b(\bar{a}) - c_1(\bar{a})]$. Thus, adoption yields a higher market share if $b(\bar{a}) > c_2(\bar{a})$. This condition is also sufficient for adoption by the Southern firm if the Northern firm does not adopt. Therefore, adopting is a dominant strategy even for the firm with the higher labelling costs. □

In the first stage, the two governments negotiate about the level of the harmonised label. Whether the harmonised label has stricter or weaker labelling requirements than the national labels cannot be said without modelling the negotiation process in detail. One way is to assume that the labels applied independently under mutual recognition, a^N and a^S, serve as upper and lower bounds for the negotiations (depending on which one

actually is higher or lower). Then the harmonised label will be somewhere in between the two independent labels. In this case, the negotiated label is a compromise solution. If the Northern firm has a cost advantage, $c_1(a) < c_2(a)$, the Northern label will serve as an upper bound, since $a^N > a^S$. If the Southern firm has a cost advantage, the reverse situation could arise if cost-differences are large enough.

A corner solution would be to use the Northern label as the harmonised label. This has been coined "eco imperialism". The crucial point about this solution is that Southern governments may be forced to adopt labels from export partners that do not match the economic conditions in the South. Yet, in our analytical setup the Southern firm nevertheless would gain from adopting such a label. As a harmonisation neutralises the home bias, it can be shown that adopting the Northern label could actually be a simple and profitable strategy (compared to the mutual recognition regime) for the Southern government, even if this label will not maximise the profit of the Southern firm and therefore Southern welfare.

Proposition 4. *If the Northern label is used as the harmonised label and a) if labelling costs are equal, $c_1(a) = c_2(a)$, the Southern firm gains by adopting the Northern label.*
b) if the Southern firm has higher labelling costs, $c_1(a) < c_2(a)$, the Southern firm gains only if the cost difference is lower than the prior home bias, $\beta > c_2(a^N) - c_2(a^S)$.
c) if the Southern label is higher under mutual recognition, $a^N < a^S$, the Southern firm always gains from adopting the Northern label.

Proof. a) With $c_1(a) = c_2(a)$, and given the home bias $b(a^N) - b(a^S) > 0$, the Northern label is the higher label under mutual recognition, $a^N > a^S$. If the home bias disappears, adopting the Northern label a^N maximises the Southern firms' profits.

b) With $c_1(a) < c_2(a)$, again $a^N > a^S$ under mutual recognition. The profit under mutual recognition is $\pi_2^{*m} = \frac{1}{18}[3 - \beta + c_1(a^N)) - c_2(a^S))]^2$ (see (28)). The profit with a harmonised label $\bar{a} = a^N$ is given by $\pi_2^h(a^N) = \frac{1}{18}(3 + c_1(a^N) - c_2(a^N))^2$. $\beta > c_2(a^N) - c_2(a^S)$ is sufficient for $\pi_2^h(a^N) > \pi_2^{*m}$, since then the additional costs from choosing a stricter label do not (over)compensate the extra benefit from a higher market share due to the abolition of a home bias.

c) If $a^S > a^N$ this implies $c_2(a^N) - c_2(a^S) < 0$ and therefore $\beta > 0 > c_2(a^N) - c_2(a^S)$ always holds. □

The idea behind proposition 4c) is that $a^S > a^N$ implies a cost advantage of the Southern firm: With mutual recognition, $b'(a^S) = c_2'(a^S) < c_1'(a^N) = b'(a^N)$, and as we have assumed strict convexity, this implies $c_2(a^S) < c_1(a^N)$ and $c_2(a) < c_1(a)$ $\forall a$. By adopting the lower Northern label, the Southern firm gains from the lack of the home bias and from a reduction in labelling costs, despite the fact that the lower label will not maximise its profits under harmonisation.

Another solution for the negotiation process would be that the governments maximise common welfare. For a social planner at the international level, the labels chosen under mutual recognition (a^N, a^S) no longer serve as a political constraint or as upper/lower bounds for harmonisation. She would have to consider the following welfare function:

$$W^h = \pi_1^{*h} + \pi_2^{*h} + CS_{net}^h + WG^h - TC \tag{37}$$

for which we get

$$W^h = \sigma^h + b(\bar{a}) + \frac{5}{36}(c_1(\bar{a}) - c_2(\bar{a}))^2 - \frac{1}{2}(c_1(\bar{a}) + c_2(\bar{a})) \tag{38}$$

with $\sigma^h = s - c - \frac{1}{12}$.

With the efficient solution, harmonisation does not necessarily imply a compromise solution, i.e. a label $\bar{a}$ that is in the range between the mutual recognition labels. Now it is conceivable that the harmonised label is even stricter than the upper bound mutual recognition label.

Proposition 5. *If the harmonised label, $\bar{a}$, is chosen efficiently,*

a) and $c_1(a) > c_2(a)$ (i.e the Southern firm has a cost advantage), then the efficient label is always stricter than the Northern label under mutual recognition, and it is stricter than the Southern label under mutual recognition if $c_1(\bar{a}) - c_2(\bar{a}) > \frac{18}{10}$

b) and $c_1(a) < c_2(a)$ (i.e the Northern firm has a cost advantage), then the efficient label is always stricter than the Southern label with mutual recognition, and it is stricter than the Northern label if $c_2(\bar{a}) - c_1(\bar{a}) > \frac{18}{10}$

c) and $-3 < c_2(\bar{a}) - c_1(\bar{a}) < 3$, then the efficient label is chosen such that it drives the firm with the higher labelling costs out of the market.

The *Proof* is given in the appendix.

As the social planner takes into account both firms' profits, profit shifting does no longer affect the welfare negatively and does not restrict the choice of the harmonised label. Compared to the situation where the two governments negotiate the harmonised label and use the mutual recognition labels as upper/lower bounds, we can conclude:

Corollary 1. *If in the negotiations about harmonisation, the labels chosen under mutual recognition are setting an upper bound for $\bar{a}$, and if the cost differences are sufficiently large (as outlined in proposition 5), the negotiated harmonised label will be inefficient from a welfare point of view.*

For this result it is crucial to assume a situation where the negotiating parties depart from independent labelling policies and where the Northern party is not willing to subscribe to a stricter label than a^N. The Northern country has a simple reason for this behaviour. It would loose twice: the home bias would disappear and labelling costs would increase. The social planner, though, would not be restricted by these bounds. Her decision would be based on the firms' cost structures, and she could choose a higher label that induces production to shift to the country with the lower costs.

A more intuitive interpretation of this result starts with the first order condition for a welfare maximum:

$$b'(\bar{a}) = \frac{1}{2}(c_1'(\bar{a}) + c_2'(\bar{a})) - \frac{5}{18}(c_1(\bar{a}) - c_2(\bar{a}))(c_1'(\bar{a}) - c_2'(\bar{a})) \qquad (39)$$

On the RHS of this equation, the marginal costs of labelling consist of production costs and transportation costs. The welfare function (38) can be rearranged to show these costs explicitly (see appendix). Therefore, the social planner faces the trade-off between welfare gains from shifting production to the region with lower labelling costs and the additional transportation costs caused by this shift. Shifting production is possible by increasing labelling requirements. The welfare maximising label implies a shift in production if the reduction in labelling costs is higher than the increase in transportation costs.

The benchmark for our interpretation on the choice of an efficient harmonised label is $c_1(\bar{a}) = c_2(\bar{a})$. In this case we have $b'(\bar{a}) = c'(\bar{a})$ as can be seen from (39). This implies, of course, that the choice of the Northern mutual recognition label, a^N as the harmonised label is efficient

– as elaborated in proposition 5. If, however, $c_1(\bar{a}) < c_2(\bar{a})$, the Northern firm has a cost advantage. If the sufficient condition in proposition (5b) is fulfilled, total costs of labelling decrease by shifting production to the North, since the reduction in production costs is higher than the increase in travelling costs. However, if the RHS of (39) decreases compared to the benchmark, marginal benefits from labelling must decrease, too, requiring a higher labelling level than in the benchmark with equal costs.

We can illustrate the welfare effects by using a simple numerical example, which we have elaborated in the appendix. The cost functions in the North and in the South are $c_1(\bar{a}) = \frac{(\bar{a})^2}{2}$ and $c_2(\bar{a}) = \upsilon\frac{(\bar{a})^2}{2}$ and with $c_i(0) = 0$, $c_i' > 0$ and $c_i'' > 0$. υ determines the degree of cost differences between labelling activities in the two countries. If both countries introduce labels, there are three cases for the cost functions, depending on the cost parameter υ.

1. $0 < \upsilon < 1 \Rightarrow c_1(\bar{a}) > c_2(\bar{a})$
2. $\upsilon = 1 \Rightarrow c_1(\bar{a}) = c_2(\bar{a})$
3. $1 < \upsilon < 2 \Rightarrow c_1(\bar{a}) > c_2(\bar{a})$

We have for the social planner's warm glow $WG^h = b(\bar{a}) = \sqrt{\bar{a}}$, and inserting the relevant numbers into (38) we have

$$W^h = \sigma^h + (\bar{a})^{\frac{1}{2}} + \frac{5}{144}(\bar{a})^4(\upsilon - 1)^2 - \frac{\bar{a}^2}{4}(1 + \upsilon). \tag{40}$$

The welfare maximising label $\bar{a}^*$ depends on the cost difference υ between North and South caused by a labelling programme. Moreover firms' profits must not become negative.

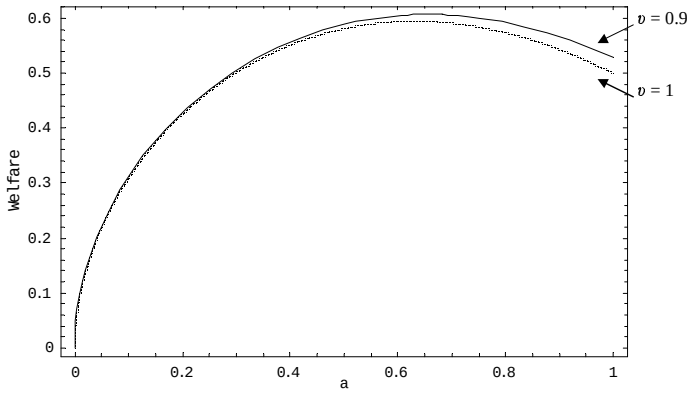
Taking the case of $\upsilon = 1$ as a benchmark, figure 2 illustrates the welfare for identical labelling costs and for a 10 per cent cost advantage of the Southern firm $\upsilon = 0.9$.

We find that welfare increases if one firm has a cost advantage (upper line). The welfare maximising label in case of identical labelling costs in North and South, $\upsilon = 1$, is $\bar{a}^* = \frac{1}{2^{\frac{2}{3}}} \approx 0.63$. With a cost advantage of 10 per cent, the optimal labelling would yield $\bar{a}^* \approx 0.65$.

2.4 Discussion of results

In our model of horizontal product differentiation we find that under mutual recognition of a Northern and a Southern label, the effects of

Figure 2: Welfare Comparison



Welfare under harmonisation with 10 per cent cost advantage of one firm.
σ = const. $\upsilon = (c_i - c_j)$, with $i = 1,2,\ i \neq j$

labelling on firms' market shares and welfare depend on how consumers value the information given by the labels, and on the costs the labelling programme imposes on the producers. A home bias of consumers leads to discrimination in the market and can only be compensated for by low labelling costs of the Southern producer. Thus, the Northern firm has the higher market share as long as the home bias is not outperformed by cost advantages of the Southern competitor. Moreover, for low labelling costs in the South there exists a critical value of the home bias up to which the Southern profits can be higher than the Northern one. However, this is only a small range of parameter values. As the Southern firm has to outperform the home bias, the incentive to cheat with respect to labelling criteria is considerable. The home bias could lead to a self-fulfilling prophecy: the Southern label is not trustworthy because Southern firms tend to undermine labelling standards to save costs, but they tend to undermine Northern standards in order to compete via prices against the home bias. This result is also important, because for the Northern firm there is no way to influence, control or monitor the Southern labelling costs. Neither has it direct command of the home bias. Thus, there is a strong incentive for the Southern firm to offer a la-

belled good which has very low labelling standards, while this behaviour contributes to the Northern firm's 'reputational' comparative advantage (see Basu et al. 2004: 136). These results are similar to the problem of adverse selection in the vertical differentiation models, e.g. by Jansen and de Faria (2002).

Under mutual recognition, a social planner would consider the Northern firm's profits, net consumer surplus, the warm glow and transportation cost. Her choice of the labelling criteria, however, would not differ from the firm's choice. Since the consumers include the benefits from labels in their demand function, all relevant environmental factors are assumed to be considered at the firm level. Moreover, and as stated in Spence (1975), the consumers identical willingness to pay assumption contributes to this result, because marginal and average willingness to pay are identical.

If there is only one harmonised single subject label in the market, and both firms accept this tool, we find that the firms differentiation stems solely from the costs of labelling as harmonisation abolishes the home bias. Each firm compares profits with a label on the one hand, and profits without a label on the other hand. As long as the marginal willingness to pay - stemming from warm glow - is larger than marginal abatement cost, firms would adopt the harmonised label. Due to the strategic interaction of firms, no one firm would refrain from using a label. Labelling is a dominant strategy.

More interesting results are driven by the home bias. First, for the Southern firm that is exporting all its output to the North, even the harmonisation at the Northern labelling level could be an optimal choice. Second, welfare analysis of a harmonised labelling programme shows that a social planner would set stricter labelling criteria compared to the mutual recognition case, if the difference in labelling costs is sufficiently large. In this case, the result of the negotiations about a harmonised label will be inefficient if the mutual recognition labels serve as upper and lower bounds. This implies that in the specific setting of no externalities but a warm glow of consumers, only an international institution that is able to enforce a common labelling programme would implement efficient labels. The mere cooperation of the Northern and the Southern government would not yield a welfare maximising result.

Finally, the externalities need some more elaboration. Beyond the warm glow one could assume negative welfare effects for the global environment stemming from the PPMs, e.g. damage from emissions. How-

ever, such considerations need a different modelling tool. The horizontal product differentiation model assumes that each consumer buys one good. If the technology is fixed, each unit of externality that is caused by the production of goods can be reduced by producing less. Yet, here reducing the number of goods means reducing the number of consumers. Nevertheless, an increase in labelling criteria can be assumed to deliver higher standards in pollution prevention and control. From our findings above, and given the limits of the model, this implies a better internalisation under harmonisation and with a social planner.

Crucial to the effectiveness of labels is of course, that consumers have the desire to contribute to a better environment. The prerequisite for the success of eco-labels with respect to their environmental impacts therefore is education and information. Moreover, the home bias and the protectionist chill it implies, can not only be cured by harmonisation, but also if under mutual recognition better information is delivered to the Northern consumer. This is a basic problem of producers in developing countries and needs to be addressed in the context of the WTO Doha Development round mandate on eco-labels.

3 Conclusions

Ecological labels are a market-based policy instrument which helps to overcome information asymmetries between consumers and producers. Especially, labels can inform about the environmental background of a product which includes its processes and production methods (PPMs). This makes labels an effective tool to differentiate homogeneous products according to their production impact on the global environment. Many developing countries, however, regard labelling as an attempt to erect new trade barriers for their export goods. Accordingly, ecological labels are a disputed issue under the negotiations of the WTO's Doha Development Round.

One feature that underlines the developing countries argument is subject to our analysis, namely, that the consumers' environmental awareness and perception of labelling information could differ with respect to domestic and to foreign suppliers. We started from the idea that consumers can experience a warm glow from buying 'green', also known as impure altruism. Consumers' awareness creates a higher willingness to pay which induces firms to differentiate 'like products' into green and

polluting versions. However, even with a label that provides information on all aspects of a products' life cycle, an information problem persists vis-a-vis foreign labels and consumers are biased. Using a horizontal product differentiation model with a Northern and a Southern producer we find that consumers' taste for a label would induce firms to use this tool, because it determines their market position. We have also taken into account that Northern consumers face a lack of information about the Southern label and this creates a home bias. If there is a regime of mutual recognition, the equilibrium outcome depends on how the home bias is related to the cost differentials between the firms. Under mutual recognition the Northern firm can gain from the consumers' home bias. This can only be compensated for by the Southern firm if it has a cost advantage that is high enough compared to the consumers' bias towards the Northern good. Thus, we find a trade-off between consumers' environmental awareness and the goods' prices. Harmonisation, on the other hand, would abolish the discrimination of the Southern product on the demand side and the market equilibrium would only depend on how firms' cost would be affected by the label. The firm facing the higher labelling cost will loose market share and profit. A social planner would set the labelling criteria higher under harmonisation than under mutual recognition given that one firm has lower labelling costs and given that the cost difference is sufficiently large. Moreover, we find that harmonisation at the importing countries' level could yield an optimal solution for the exporting firm.

Additionally, and in line with Eriksson (2004), we can argue that a home bias could be reduced if education and information of the importing countries' consumers about foreign labels would become better and more homogenous compared to the information on Northern labels. This would contribute to making labels a more effective policy tool for pollution control.

Labels can be regarded as a tool which promotes international environmental protection without compromising the trade rules. However, in the perception of developing countries – and most likely also in the real world of trade flows – labels may act as a barrier to trade for comparable products not receiving an importing country's domestic label. Nevertheless, developing countries with strong dependence on export markets should consider a cooperation with importing countries on giving product information also on the processes and production methods. This could be conducted through both, mutual recognition agreements or a har-

monised labelling programme. The arguments we are stressing from the analytical point of view are, first, that developing countries should not dismiss harmonisation from the outset and, second, a credible institution is needed to coordinate the application of labels, and this should be integrated in and acknowledged by the international trade regime. In order to find practicable and efficient solutions, the implementation of labelling coordination that serves both, developing and industrial countries, needs further analyses and discussions.

A Appendix

A.1 Welfare Analysis under Harmonisation of Labels

Welfare (38) can be rearranged to show that total costs C consist of production cost PC and transportation cost TC.

$$W^h = s + b(\bar{a}) - (\underbrace{[c_1(\bar{a})\hat{x}^h + c_2(\bar{a})(1-\hat{x}^h)]}_{PC} + \underbrace{[\frac{1}{3} + (\hat{x}^h)^2 - \hat{x}^h]}_{TC})$$

Inserting (33) and (34) implies for total costs C

$$C = PC{+}TC = \underbrace{[\frac{1}{2}(c_1(\bar{a}) + c_2(\bar{a})) - \frac{1}{6}(c_2(\bar{a}) - c_1(\bar{a}))^2]}_{PC} + \underbrace{[\frac{1}{12} + \frac{1}{36}(c_2(\bar{a}) - c_1(\bar{a}))^2]}_{TC}$$

If $\Delta = c^2 - c^1$ denotes the cost difference, total costs can be rewritten as

$$C = \frac{1}{2}(\Delta + 2c_1) - \frac{1}{6}\Delta^2 + \frac{1}{12} + \frac{1}{36}\Delta^2 \tag{A.1}$$

The effect of an increase in the cost differential on total costs is

$$\frac{\partial C}{\partial \Delta} = \frac{1}{2} - \frac{5}{18}\Delta \tag{A.2}$$

Therefore, total costs decrease if $\Delta > 18/10$. But when total costs decrease, marginal benefits $b'(\bar{a})$ must decrease too, requiring a higher labelling level.

A.2 Proof of Proposition 5

a) Due to the assumed strict convexity of the labelling costs, $c_1(a) > c_2(a)$ implies $c_1'(a) > c_2'(a)$. With mutual recognition, the chosen labels are $b'(a^N) = c_1'(a^N)$ and $b'(a^S) = c_2'(a^S)$. If the harmonised label is stricter than the Northern label, $\bar{a} > a^N$, then $b'(\bar{a}) < b'(a^N)$.
Suppose the contrary, i.e. $\bar{a} < a^N$, which would imply $b'(\bar{a}) > b'(a^N) = c_1'(a^N)$. Inserting (39)

$$\frac{1}{2}(c_1'(\bar{a}) + c_2'(\bar{a})) - \frac{5}{18}(c_1(\bar{a}) - c_2(\bar{a}))(c_1'(\bar{a}) - c_2'(\bar{a})) > c_1'(a^N) \tag{A.3}$$

and subtracting $c_1'(\bar{a})$ from both sides gives

$$\frac{1}{2}(c_2'(\bar{a})-c_1'(\bar{a}))-\frac{5}{18}(c_1(\bar{a})-c_2(\bar{a}))(c_1'(\bar{a})-c_2'(\bar{a})) > (c_1'(a^N)-c_1'(\bar{a})) \quad \text{(A.4)}$$

or

$$[-\frac{1}{2}-\frac{5}{18}(c_1(\bar{a})-c_2(\bar{a}))][c_1'(\bar{a})-c_2'(\bar{a})]) > (c_1'(a^N)-c_1'(\bar{a})). \quad \text{(A.5)}$$

On the LHS, the first bracketed term is negative due to the assumption $c_1(\bar{a}) > c_2(\bar{a})$, and the second bracketed term is positive, therefore the LHS is negative. But if $a^N > \bar{a}$, $c_1(a^N) > c_1(\bar{a})$ and $c_1'(a^N) > c_1'(\bar{a})$, therefore the RHS is positive, which yields a contradiction. Therefore, $a^N > \bar{a}$ is not possible.
For the comparison with the Southern label, suppose the contrary, i.e. $\bar{a} < a^S$, which would imply $b'(\bar{a}) > b'(a^S) = c_2'(a^S)$. Inserting (39) and substracting $c_2'(\bar{a})$ from both sides gives

$$\frac{1}{2}(c_1'(\bar{a})-c_2'(\bar{a}))-\frac{5}{18}(c_1(\bar{a})-c_2(\bar{a}))(c_1'(\bar{a})-c_2'(\bar{a})) > (c_2'(a^S)-c_2'(\bar{a})) \quad \text{(A.6)}$$

or

$$[\frac{1}{2}-\frac{5}{18}(c_1(\bar{a})-c_2(\bar{a}))][c_1'(\bar{a})-c_2'(\bar{a})]) > (c_2'(a^S)-c_2'(\bar{a})). \quad \text{(A.7)}$$

The RHS is positive if $a^S > \bar{a}$. The second bracket on the LHS is positive, therefore if the term in the first bracket is negative, a contradiction arises. Sufficient for this is $\frac{1}{2}-\frac{5}{18}(c_1(\bar{a})-c_2(\bar{a})) < 0$ or $c_1(\bar{a})-c_2(\bar{a}) > \frac{18}{10}$.
Therefore, if the difference in labelling costs is sufficiently high, $\bar{a} < a^S$ is not possible.
b) For the comparison with the Southern label under mutual recognition, suppose the contrary, $\bar{a} < a^S$, which would imply $b'(\bar{a}) > b'(a^S) = c_2'(a^S)$. Inserting (39), substracting $c_2'(\bar{a})$ from both sides and rearranging terms gives again (A.7). As before, the RHS is positive. On the LHS, the second bracket is negative due to $c_1(a) < c_2(a)$, and the first bracketed term is positive, which implies the contradiction. Therefore, $\bar{a} < a^S$ is not possible.
For the comparison with the Northern label, suppose the contrary, $\bar{a} < a^N$, which would imply $b'(\bar{a}) > b'(a^N) = c_1'(a^N)$. Inserting (39), substracting $c_1'(\bar{a})$ from both sides gives

$$[-\frac{1}{2}-\frac{5}{18}(c_1(\bar{a})-c_2(\bar{a}))][c_1'(\bar{a})-c_2'(\bar{a})]) > (c_1'(a^N)-c_1'(\bar{a})). \quad \text{(A.8)}$$

The RHS is positive, the second bracket on the LHS is negative. Therefore, if the term in the first bracket is positive, a contradiction will result. Sufficient for this is $c_2(\bar{a}) - c_1(\bar{a}) > \frac{18}{10}$.
c) Follows directly from (33) and (34) as a condition for a corner solution.

A.3 Numerical Example

We use as cost functions in the North and in the South $c_1(\bar{a}) = \frac{(\bar{a})^2}{2}$ and $c_2(\bar{a}) = \upsilon\frac{(\bar{a})^2}{2}$, with $c_i(0) = 0$, $c_i' > 0$ and $c_i'' > 0$. υ determines the degree of cost differences between labelling activities in the two countries. If both countries introduce labels, there are three cases for the cost functions, depending on the cost parameter υ.

1. $0 < \upsilon < 1 \Rightarrow c_1(\bar{a}) > c_2(\bar{a})$
2. $\upsilon = 1 \Rightarrow c_1(\bar{a}) = c_2(\bar{a})$
3. $1 < \upsilon < 2 \Rightarrow c_1(\bar{a}) > c_2(\bar{a})$

We have for the social planner's warm glow $WG^h = b(\bar{a}) = \sqrt{\bar{a}}$, and inserting the relevant numbers into (38) we have

$$W^h = \sigma^h + (\bar{a})^{\frac{1}{2}} + \frac{5}{144}(\bar{a})^4(\upsilon - 1)^2 - \frac{\bar{a}^2}{4}(1 + \upsilon). \tag{A.9}$$

The welfare maximising label $\bar{a}^*$ depends on the cost difference υ between North and South caused by a labelling programme. Moreover we have as a constraint that firms' profits must not become negative.

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